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NUCLEAR TERRORISM: AN OVERVIEW*

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Perhaps the most common conception of 'nuclear terrorism' is the ruins of a major city in which thousands have died from the effects of a rudimentary nuclear device planted by terrorists. Fortunately, this is probably the least likely form of nuclear terrorism. Unfortunately, there are a number of other forms, all of which are considerably easier and safer for the perpetrators, than the detonation of a full-fledged nuclear weapon.

This paper will provide an overview of the major possible forms of nuclear terrorism and assess the risks associated with each. It will also deal with the single most important determinant of whether or not most forms of nuclear terrorism could take place: illicit access to fissile and radioactive materials. The paper will argue that the detonation of a true nuclear weapon by terrorists[1] is probably the least likely scenario, and that other more probable forms of nuclear terrorism include the use of radiological dispersal devices (RDDs) or 'dirty bombs', and attacks on nuclear reactors and the nuclear fuel cycle.

The Russian Marketplace: A Source for Nuclear Terrorism?

When the Soviet Union collapsed in 1991, there was immediate, widespread concern about the fate of its nuclear arsenal, which was dispersed among at least 14 of the Soviet republics, and about security in the former USSR's huge nuclear military-industrial complex. For a time, Ukraine, Belarus and Kazakhstan existed in virtual anarchy, with no clarity as to how, and by whom, the weapons were to be controlled. They soon renounced their nuclear status, however, and returned their weapons to Russia.

The fear of uncontrolled weapons falling into the hands of terrorists then largely abated, although it was reawakened by the 1997 claim by former Russian Security Council chief General Alexander Lebed that he could account for only 48 of 100 backpack-sized nuclear weapons. This drew attention to the very poor, even haphazard, standards of control and accounting that prevailed in the Soviet Union and its successor, the Russian Federation. (However, there has been no suggestion that the notorious 'suitcase nukes' ever reached terrorists or other clandestine proliferators, if indeed some were actually missing. In any case, by now they would probably not be useable except as sources of fissile materials.[2])

Security in the former Soviet Union's (FSU) nuclear complex continues to be a pressing concern. As recently as 1995, 30 tonnes of separated plutonium were stored in an ordinary warehouse, 'secured' with a padlock, at a facility in Mayak, Russia. To deal with these lapses, a number of joint US-Russian programs are attempting to address the two major nuclear security issues in the FSU: the physical security of radioactive materials, and the problem of the tens of thousands of unemployed or underemployed nuclear technicians, engineers and scientists in the formerly 'secret cities' of the nuclear complex. Chief among them are the Nuclear Cities Initiative (NCI), Initiatives for Proliferation Prevention (IPP), and the International Science and Technology Center (ISTC). These programs have been unsuccessful, especially in their attempts to find alternative employment for former nuclear workers who might be tempted to sell their nuclear expertise, or even nuclear materials, to the highest bidders. This seems to be largely because the present Bush Administration appears to see these programs as foreign-aid handouts to a former foe, and not as investments in American and international security.[3] In 2001, for instance, US funding for NCI was cut by 75%. Nonetheless, physical security is improving in some areas.

Non-military radiation sources in the FSU are, or should be, an even more serious source of concern. During the Soviet era, a large number of powerful radiation sources accumulated in various facilities and were either stored, thrown out, or sold in an uncontrolled fashion.[4] A number of radioisotopic thermoelectric generators (commonly used in unmanned lighthouses) containing significant quantities of highly radioactive strontium-90 have allegedly been lost to any control or monitoring, or simply lost altogether.

This state of affairs has heightened concerns over the smuggling of radioactive materials from the FSU. Fortunately, despite the dire predictions of the early 1990s, the expected flood of radiation across the FSU's newly porous borders has failed to materialize. There has certainly been smuggling, but the amounts and nature of the interdicted materials suggest that it amounts only to a trickle and that it is driven by the supply side –

typically, amateurish opportunists who steal radioactive material and only later try to find a buyer – with little demand from either organized crime[5] or terrorist organizations.

The IAEA's database on global trafficking in nuclear and radioactive sources contains 540 confirmed instances between 1993 and 2003, of which "182 incidents involved nuclear material, 335 incidents involved radioactive material other than nuclear material, and 23 incidents involved both nuclear and other radioactive materials". These numbers may seem alarmingly large, but the IAEA points out that only 17 incidents involved weapons-useable highly enriched uranium (HEU) or plutonium. In the early 1990s, "quantities of a kilogram or more of HEU were seized in a few cases, and in one case about 0.3 kg of plutonium was seized," but since 1995 no confirmed theft or seizure has involved more than 1-2 percent of the amount required for a nuclear weapon.[6]

Some of the concern with the FSU might be somewhat misplaced. Alan Kuperman has suggested that security in the West, especially around HEU in civilian hands, is such that "Osama bin Laden may soon have better luck shopping for nuclear bomb material in Western markets than in the former Soviet Union".[7]

The Difficulty of Nuclear Bomb-making

Even if terrorists could obtain enough fissile materials, opinions are divided as to whether they could build a true nuclear weapon – one that derived its explosive power from nuclear fission. There are at least four major sets of problems that terrorists would have to solve before setting off an atomic bomb: (i) obtaining enough weapons-useable fissile material (HEU or plutonium); (ii) designing the device; (iii) fabricating it, and; (iv) delivering it to the target.

The first would seem to make the entire project almost impossible. It is well known that even states that have dedicated enormous resources to the endeavour – such as Iran, Libya, and North Korea – have had considerable difficulty assembling enough fissile material for even a few warheads, especially because they were obliged to do so clandestinely. While proliferant states are usually interested in developing indigenous capabilities to enrich uranium or extract plutonium from spent reactor fuel, it is difficult to imagine why they would not try to buy weapons-grade fissiles 'off the shelf, perhaps from disaffected Russian scientists or technicians, especially if they intended to use their weapons as bargaining chips for aid and concessions from the West. Even the nuclear black market developed by Pakistan's notorious Dr. Abdul Qadeer Khan, the 'father' of that country's nuclear program, appears to have distributed nuclear technology in the form of hardware and antiquated Chinese bomb designs, rather than fissile materials.

Nontheless, it has been suggested that even powdered uranium oxide reactor fuel could be used in an improvised nuclear weapon. The amount required would be very large – tens of kilograms or possibly more – even in a relatively efficient implosion device, while the amount required to ensure a nuclear yield from a gun-type bomb would make powder unusable for that purpose, unless a very specialized press were obtained.[8] As our brief review of nuclear smuggling showed, however, all the evidence suggests that fissile materials, when they are smuggled at all, are smuggled in tiny quantities, and that there is little to suggest that large amounts of reactor fuel have gone astray. There is, however, the troubling case of a 19.9% enriched uranium fuel (low enriched uranium, or LEU) element that was seized in Italy in 1998 from criminals trying to sell it, apparently to unnamed Middle Eastern countries. It is widely thought that it was one of two fuel assemblies that went missing in the 1970s from a TRIGA research reactor in the Congo and that is still operating under extraordinarily poor security.[9]

Many claim, correctly, that conceptual drawings for both types of fission devices have been in the public domain almost since the first bombs were detonated. However, these are a far cry from what is needed to build a bomb. J. Carson Mark *et al* claim that the preparation of useable engineering plans would require many hours of labour by people with specialized skills in a number of different engineering, chemical, and physical disciplines. They say that "the necessary attributes [of the nuclear weapon construction team] would be quite distinct from the paramilitary capability most often supposed to typify terrorists".[10] At the same time, though, we should remember that the standards of safety, reliability, efficiency, and so forth required by terrorists would be very much lower than those set for professional bomb designers.

The construction facility itself might have to be built from scratch and then equipped with a fairly large amount of electrical, metalworking, and chemical equipment, as well as radiation shielding, all of which might be difficult to assemble without raising suspicion. With regard to shielding, even would-be martyrs would have to stay alive long enough to complete the construction. (Not incidentally, it is probably fair to assume that a lingering death from radiation sickness or cancer would be much harder to sell to the older, skilled personnel who would be required than the quick, explosive trip to heaven that is offered to the discouraged youngsters who are the typical fodder for suicide missions.)

Whatever kind of nuclear weapon terrorists were able to build, assuming they had access to the materials and skills, it would almost certainly be very large, weighing a ton or more.[11] It is clearly within terrorists' abilities to deliver such large loads to their targets – consider Oklahoma City, the first World Trade Center attacks, and other large truck and car bombs – but it would require the weapon to be either assembled in the target state or shipped, probably in a container, from the country of origin. Security at many seaports is notoriously poor and what inspection there is is typically directed towards interdicting drugs, making it entirely possible to deliver a bomb directly to a major city.

Nuclear Terrorism and the Real Threat of 'Dirty Bombs'

True nuclear weapons, however, are probably the least of our worries. Non-fissile radiation sources used in commercial, industrial, and medical facilities are particularly worrisome, if only because they are kept under significantly lower security than reactor fuels or military materials, and because they were created for the express purpose of generating intense ionising radiation.[12] The Center for Nonproliferation Studies (CNS) says that "tens of thousands" of the millions of commercial radiation sources worldwide "pose inherently high security risks because of their portability, dispersability, and higher levels of radioactivity".[13] In the United States, as many as 375 radiation sources became orphaned, or

"lost to institutional control", in a single year and only a little more half, on average, are ever recovered.[14]

Despite the very real risks arising from the various kinds of 'loose' radioactive materials around the world, however, there has been remarkably little evidence that terrorists have or would use them. So far, there has been only one known terrorist incident involving radioactive materials: Chechen separatists placed an RDD containing an unknown amount of cesium-137 in a Moscow park in 1995. A Chechen rebel leader alerted the media and the bomb was never detonated, so the entire incident amounted to a publicity stunt, albeit an extremely dangerous one.

Radiation dispersal devices are, as we have suggested, much easier to build and deliver than true nuclear weapons. All that is required is a radiation source and a means of distributing the radiation. The first, as we have seen, may not be much of an obstacle to determined terrorists, and the second certainly is not. The stereotypical RDD is a home-made device, perhaps a pipe or fertilizer bomb incorporating radioactive material that would be powdered or vaporized by the blast. This could be extremely effective, but it is not the only, nor even necessarily the most effective way of spreading radiation. One could simply drop an unshielded radiation source, such as a cobalt-60 rod from a food irradiation facility, near a pedestrian bottleneck, an entrance to a subway station or stadium and perhaps, to allow people to irradiate themselves. It could remain in place for a considerable time, possibly irradiating and re-irradiating tens of thousands of people, before the victims became symptomatic and epidemiological techniques traced their radiation sickness to its source.

Cesium-137 would be an effective choice for RDDs designed to distribute radiation actively, rather than passively, as in the previous example. It is not particularly difficult to obtain, as it is used in medical devices and in oil prospecting and drilling. Chemically, it is one of the most reactive substances known. If distributed as a powder, perhaps by an aircraft or snow sanding truck, it would bond to concrete and other surfaces, rendering them all-but impossible to decontaminate. It also has particular affinity to human muscle and is quickly and easily absorbed.

However, food irradiation rods (measuring about one foot in length and one inch in diameter) are probably the best overall candidates for use in RDDs. They are used in large numbers in the food processing industry. In 2002 the Federation of American Scientists (FAS) prepared a number of RDD scenarios for the US Senate Committee on Foreign Relations. One, involving the detonation of an RDD containing a single cobalt-60 rod in Manhattan, concluded that the contamination would be comparable to that caused by the Chernobyl reactor meltdown. "[A]n area of approximately one-thousand square kilometers, extending over three states, would be contaminated" and "[i]t would be decades before the city was inhabitable again, and demolition might be necessary".[15] These conclusions are somewhat controversial; the American Nuclear Regulatory Commission (NRC) took issue with some of the conclusions, especially the claim that the worst contaminated areas would have to be condemned.

The next area of concern embraces the safety of nuclear reactors and the nuclear fuel cycle, from fabricating the fuel to the disposal of waste. Security issues stem from the fact that commercial power-generating reactors:

- Are not designed (or at least their operators not required by the NRC to design them) "for the specific purpose of protection against the effects of ... attacks and destructive acts, including sabotage, directed against the facility by an enemy of the United States, whether a foreign government or other person"[16];

- May be vulnerable to aircraft strikes such as those that destroyed the World Trade Centre, New York, in 2001;

- Are guarded by private-sector security firms employing individuals with limited and ambiguous powers, possibly sub-standard training and, typically, low rates of pay;

- Are often located close to major metropolitan centres;

- Are capable, in certain circumstances, of total 'Chernobyl-style' meltdown even after emergency shutdown;

- House large quantities of highly radioactive spent fuel under security that is typically significantly poorer than that around the reactor itself, and;

- Are already the objects of fairly widespread public concern regarding their safety, even under normal operating conditions, which raises the amount of potential social disruption that any terrorist incident could cause;

Non-commercial (e.g. military and research) reactors have their own particular characteristics that would influence their suitability as terrorist targets.

- Regardless of their size or power, military and US Department of Energy reactors are not required by the NRC or any other authority to have containment buildings, although some do;

- Low power research reactors on university campuses typically have no containment buildings and little or no security

Finally, we must remember that not all nuclear reactors are subject to regulatory regimes comparable to those applying in Europe or North America.

The typical nuclear power reactor appears, on superficial inspection, to be well-protected beneath its reinforced concrete containment building. However, many writers, including one writing ten years before the event[17], have claimed that these buildings would not be proof against aircraft strikes of the kind that took down the World Trade Center. The NRC's Fact Sheet on Nuclear Security Enhancements Since Sept. 11, 2001 makes only passing reference to the possibility of aircraft strikes on reactors - a startling omission given the nature of the events referred to in its title.[18]

The NRC's own glossary[19] defines containment buildings as 'gastight', with no reference to physical strength. Of course, in order to be gastight against the worst possible incident - an explosion or meltdown - a containment building must necessarily be very robust. Nonetheless, the fact that some research and military reactors lack even this level of security is obviously cause for concern.

The NRC *Regulations* have been amended to require operators to provide for defence against armed attackers and truck bombs.[20] However, they do not specify how powerful the bomb might be, and the attackers are limited to automatic weapons, which ignores the very much greater risks posed by other portable

weapons such as shoulder-fired anti-tank or anti-aircraft missiles.

Various observers are concerned about the level of training, equipment, and authority of the private security guards at commercial reactors. The Project on Government Oversight (POGO) claims to have interviewed guards at 23% of the operating and one decommissioning nuclear power reactors, as well as a National Guardsman protecting the perimeter of a plant. It describes them as "Under-Manned, Under-Equipped, Under-Trained, Underpaid and Unsure about the Rules."[21] Paul Leventhal of the NCI says in a similar vein that "[a]llowing the plants to continue operating with inadequate security, in some cases only tens of miles from major cities like New York, Philadelphia, Cleveland, Chicago, Charlotte and Los Angeles, is unconscionable. Millions of people are at risk in the event of a successful attack causing severe damage to the reactor core or spent fuel pool at these plants."[22]

Conclusion

Some of the following recommendations address issues that were not discussed in detail, but are nonetheless salient.

- The FSU's decrepit military and civilian nuclear complex must be seen as a real and immediate threat to global security. Steps must be taken to support and extend the existing Russian-American initiatives and to develop new ones.

- Research reactors running on HEU and all HEU in civilian hands worldwide should be closely monitored. In many cases it may be necessary to either shut them down or convert them to run on other fuels in order to prevent unauthorized access to weapons-useable material.

- National ports of entry and international harbours and airports, in particular, must be equipped with systems capable of detecting even well-shielded radioactive materials.

- The training and compensation of guards employed at civilian reactors must be improved to the extent that all sites can at, at the barest minimum, adequately address the NRC's 'design basis threats' or DBTs.[23]

- Consideration should be given to protecting reactors against aircraft strikes well beyond the measures mentioned in the NRC's "Fact Sheet on Nuclear Security Enhancements Since Sept. 11, 2001".

- In general, protecting nuclear reactors and the fuel cycle should be seen as a matter of national and international security and not as an unreasonable burden on private industry.

- Security around commercial, industrial, and medical radiation sources must be improved to prevent theft of hazardous materials.

- All militant groups must be monitored for signs of active interest in nuclear terrorism. This monitoring should extend beyond the usual radical Islamist suspects to include domestic right/left-wing anti-government bodies and individuals, 'eco-terrorists', nationalist-separatists, and cultists of various sorts.

Some of these issues are being addressed by various governments and organisations. Nonetheless, it is clear that there are many possible avenues that terrorists wishing to 'go nuclear' could follow, and that preventing nuclear terrorism should involve a far more extensive, coordinated, and comprehensive strategy than has been the case thus far.

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Notes:

[1]In this context we use 'terrorists' to refer exclusively to sub- and transnational groups, or individuals, acting with little or no state sponsorship. The use by states of small, informal groups to clandestinely construct or deliver nuclear weapons is beyond our scope.

[2]*Cf.* Nikolai Sokov "Suitcase Nukes": A Reassessment", Center for Nonproliferation Studies, Monterey Institute of International Studies, September 23, 2002 (http://cns.miis.edu/pubs/week/020923.htm).

[3]*Cf.* Sharon S. Weiner "Preventing Nuclear Entrepreneurship in Russia's Nuclear Cities", *International Security* 27.2 (2002).

[4]Leonid Bolshov, Rafael Arutunyan and Oleg Pavlovsky, "Radiological Terrorism" in: Committee on Confronting Terrorism in Russia (Sigfried S. Hecker, Chair) *High Impact Terrorism: Proceedings of a Russian-American Workshop* (Washington: National Academy Press, 2002) p.141.

[5]John Deutch, former CIA director, quoted in Rensselaer W. Lee III, *Smuggling Armageddon: The Nuclear Black Market in the Former Soviet Union* (New York: St. Martin's Press, 1998), p. 19.

[6]IAEA "Facts & Figures: Illicit Nuclear Trafficking Statistics: January 1993 - December 2003" (http://www.iaea.org/NewsCenter/Features/RadSources/Fact_Figures.html).

[7]Alan J. Kuperman, "Loose Nukes of the West", Washington Post, Wednesday, May 7, 2003, Page A31, reproduced on http://www.nci.org/index.htm (framed site, no specific page URLs).

[8]J. Carson Mark, Theodore Taylor, Eugene Eyster, William Maraman, Jacob Wechsler "Can Terrorists Build Nuclear Weapons?" in Paul Leventhal and Yonah Alexander (eds.) *Preventing Nuclear Terrorism* (Lexington, MA/Toronto: Lexington Books, 1987).

[9]*Cf.* George Bunn and Matthew Bunn, "Reducing the Threat of Nuclear Theft and Sabotage", paper delivered at International Atomic Energy Agency (IAEA) Symposium, October 30, 2001 (http://www.iaea.org/NewsCenter/Features/Nuclear_Terrorism/bunn02.pdf).

[10]J. Carson Mark, *et al*, *ibid.*, pp. 58-59.

[11]Mark *et al*, *ibid*, p. 50.

[12]Bolshov, Arutunyan, and Pavlovsky, "Radiological Terrorism" *op. cit.*, p.141.

[13]Charles D. Ferguson, Tahseen Kazi, Judith Perera *Commercial Radioactive Sources: Surveying the Security Risks*, Occasional Paper No. 11, Centre for Nonproliferation Studies, Monterey Institute for International Studies, January 2003, p. 17 (http://cns.miis.edu/pubs/opapers/op11/op11.pdf).

[14]Ferguson *et al*, "Commercial Radioactive Sources", p. v.

[15]Dr Henry Kelley, testimony before Senate.

[16]Nuclear Regulatory Commission, *NRC Regulations*, Part 50.13, "Attacks and destructive acts by enemies of the United States; and defense activities" (http://www.nrc.gov/reading-rm/doc-collections/cfr/part050/part050-0013.html).

[17]Alexander Yefremov, *The Atom Bomb on the Black Market*, (Moscow: Novosti Press Agency Publishing House, 1990), p. 31.

[18]Nuclear Regulatory Commission (NRC) "Fact Sheet on Nuclear Security Enhancements Since Sept. 11, 2001", (http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/security-enhancements.html).

[19]"A gastight shell or other enclosure around a nuclear reactor to confine fission products that otherwise might be released to the atmosphere in the event of an accident." (http://www.nrc.gov/reading-rm/basic-ref/glossary/containment-structure.html).

[20]NRC *Regulations*, 73.1(a)i.

[21]POGO.org, "Nuclear Power Plant Security: Voices from Inside the Fences", (http://www.pogo.org/p/environment/eo-020901-nukepowerb.html#guards).

[22]NCI press release quoting Paul Leventhal, NCI president "President Says Terrorists Had Diagrams Of Nuclear Power Plants; NRC Must Move Now On Major Upgrade Of Security Against Attack" (http://www.nci.org/, framed site, specific URL not possible).

[23]Nuclear Regulatory Commission, "NRC Regulations (10 CFR), Part 73 – Physical Protection of Plants and Materials" (http://www.nrc.gov/reading-rm/doc-collections/cfr/part073/full-text.html).

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